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APPLICATION FOR

UNITED STATES LETTERS PATENT

FOR

TRACK LIGHTING SYSTEM FOR 277 VOLT POWER LINE

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that I, OLE KRISTIAN NILSSEN, a citizen of Norway, residing at Caesar Drive, Route 5, Barrington, Illinois, County of Cook, United States of America, have invented a

501 TRACK LIGHTING SYSTEM FOR 277 VOLT POWER LINE

of which the following is a specification.

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BACKGROUND OF THE INVENTION

Field of Invention

The present invention relates to a track lighting system adapted to be powered from a 277 Volt power line, yet -- by way of an electronic voltage conditioner -- operative to provide 120 Volt voltage on the power track, thereby permitting the use therein of ordinary 120 Volt incandescent lamps.

Prior Art

For reasons of cost-effectivity, electric power distribution in commercial buildings is preferably accomplished by way of a 277 Volt distribution voltage.

However, if a track lighting system is installed, it is necessary to use a distribution voltage of 120 Volt RMS magnitude; otherwise, it would be necessary to use very special incandescent light bulbs in the power tracks and/or to provide a very special voltage-magnitude-transformation means between the 277 Volt power line and the power tracks.

In commercial lighting systems where the predominant lighting means are gas discharge lamps, the distribution voltage of choice is 277 Volt. However, in combination with a gas discharge lighting system it is frequently necessary to provide for incandescent track lighting as well. Yet, available incandescent lamps are designed for operation on 120 Volt; which implies the necessity in such situations of providing for some sort of voltage-magnitude-transformation means. In present 277 Volt installations, voltage-magnitude-transformation means for incandescent lamps are provided in the form of 60 Hz voltage step-down transformers. However, within economically realistic limits, such transformers are highly inefficient and very heavy.

SUMMARY OF THE INVENTION

Objects of the Invention

An object of the present invention is that of providing a track lighting system operable to be powered by a relatively high-magnitude voltage, such as 277 Volt, yet being cost-effectively operative to properly power lamps designed to operate on a relatively low-magnitude voltage, such as 12 or 120 Volt.

More specifically, an object of the present invention is that of providing a track lighting system powered from a 277 Volt power line, yet cost-effectively operable to permit use therein of incandescent lamps designed for operation on 120 Volt.

These, as well as other objects, features and advantages of the present invention will become apparent from the following description and claims.

Brief Description

In its preferred embodiment, the present invention is a track lighting system adapted to be powered from a 277 Volt AC power line and operative to provide on its power tracks proper voltage for powering ordinary 120 Volt incandescent lamps.

The 120 Volt power track voltage is obtained by way of an integral electronic transformer-less voltage conditioner. This voltage conditioner includes a full-bridge rectifier providing an unfiltered DC supply voltage consisting of sinusoidally-shaped unidirectional voltage pulses having an RMS magnitude of 277 Volt. In fact, the instantaneous magnitude of this DC supply voltage is substantially equal to that of the 277 Volt AC voltage.

The DC supply voltage is provided to a half-bridge inverter; which, as long as it is in operation, provides a high-frequency (i.e., about 30 kHz) output voltage of RMS magnitude equal to half that of the DC supply voltage. By arranging for the inverter to operate only during part of each of the unidirectional voltage pulses provided from the full-bridge rectifier, the RMS magnitude of the inverter's output voltage can readily be adjusted to have an RMS magnitude somewhat lower than half of 277 Volt -- such as 120 Volt.

Since the major part of the voltage-magnitude-reduction is accomplished by way of the half-bridge inverter action itself -- which action naturally provides for a halving of the voltage magnitude of the inverter's AC output voltage as compared with that of its DC supply voltage -- the resulting power factor of the power drawn from the 277 Volt power line is excellent: better than 85%. Moreover, the overall efficiency is very much better than that attainable with ordinary 60 Hz transformers: on the order of 95% or better.

Since the frequency of the 120 Volt power track voltage is relatively high (i.e., about 30 kHz), it becomes cost-effectively feasible to use 12 Volt Tungsten-Halogen lamps in the system's track lighting units. The 12 Volt RMS required for properly powering these Tungsten-Halogen lamps is obtained by way of very compact and highly efficient high-frequency ferrite transformer means.

4

Brief Description of the Drawings

Fig. 1 provides a basic electrical circuit diagram of the preferred embodiment of the invention.

Fig. 2 provides a schematic diagram of a larger-scale lighting system constructed in accordance with the present invention.

Fig. 3 illustrates a first track lighting system constructed in accordance with the present invention.

Fig. 4 illustrates a second track lighting system constructed in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Details of Construction

Fig. 1 schematically illustrates the electrical circuit arrangement of subject track lighting system.

An electronic voltage conditioner EVC is connected with power line conductors PLC of a 277Volt/60Hz power line, and provides an output of 120Volt/30kHz across a pair of output and distribution conductors ODC.

A number of 120 Volt lighting units LU1, LU2 --- LUn are connected with output and distribution conductors ODC.

Lighting unit LU1 consists of an ordinary 120 Volt incandescent lamp OIL, and lighting unit LU2 consists of a 12 Volt Tungsten-Halogen lamp THL connected with conductors ODC by way of a high-frequency ferrite transformer HFFT.

Within electronic voltage conditioner EVC, a full-bridge rectifier FBR is connected with the 277Volt/60Hz power line conductors (PLC) and provides its rectified output across a B+ bus and a B- bus, with the B+ bus being of positive polarity.

A half-bridge inverter HBI is connected with the B+ bus and the B- bus; and the 120Volt/30kHz output from this inverter is provided across output and distribution conductors ODC.

Within half-bridge inverter HBI, connected between the B+ bus and a junction JC, is a first capacitor C1; and connected between junction JC and the B- bus is a second capacitor C2.

Connected with the B+ bus and a junction JQ are the collector and the emitter, respectively, of a first transistor Q1; and, similarly, connected with juntion JQ and the B- bus are the collector and the emitter, respectively, of a second transistor Q2.

Secondary winding CT1s of saturable current transformer CT1 is connected between the base and the emitter of transistor Q1; and secondary winding CT2s of saturable current transformer CT2 is connected between the base and the emitter of transistor Q2. The primary windings of current transformers CT1 and CT2 are connected in series between a point X and junction JQ.

A fixed resistor FR is connected in series with an adjustable resistor AR to form a series-combination; and this series-combination is connected between the B+ bus and a junction Jt. A capacitor Ct is connected between junction Jt and the B- bus; a Diac D1 is connected between junction Jt and the base of transistor Q2; and a diode D2 is connected with its anode to junction Jt and with its cathode to junction JQ.

Output and distribution conductors ODC are connected between junction JC and point X.

Fig. 2 illustrates a situation where a plurality of electronic voltage conditioners EVC1, EVC2 --- EVCn are each connected with a single pair of 277Volt/60Hz power line conductors PLC. Connected with EVC1 are lighting units LU1a, LU1b --- LU1x; connected with EVC2 are lighting units LU2a, LU2b --- LU2y; and connected with EVCn by way of power track PTn are lighting units LUna, LUnb --- LUnz.

Fig. 3 illustrates more specifically a track lighting system wherein an electronic voltage conditioner EVCt is powered from 277Volt/60Hz power line conductors PLC and provides a 120Volt/30kH output by way of a pair of output and distribution conductors ODC to a pair of track input conductors TIC to a power track PT having a track receptacle slot TRS, into which track receptacle slot are inserted a number of track lighting units TLU1, TLU2 --- TLUm.

Fig. 4 illustrates an arrangement wherein a special electronic voltage conditioner SEVC has been integrated with a special power track SPT, thereby to render this special power track operable to connect directly with 277Volt/60Hz power line conductors PLC and to provide 120Volt/30kHz on its special track conductors STC; which special track conductors are shown in cut-away section CAS of the special power track. Inserted into and held by a special track receptacle slot STRS of this special power track are special track lighting units STLU1, STLU2 --- STLUm. Special track lighting unit STLU1 comprises an ordinary 120 Volt incandescent lamp OIL adapted to connect directly with special track conductors STC. Special track lighting unit STLU2 comprises a 12 Volt Tungsten-Halogen lamp THL connected with special track conductors STC by way of high-frequency ferrite transformer HFFT and low-frequency blocking capacitor LFBC.

Details of Operation

In Fig. 1, the 277Volt/60Hz power line voltage provided from the power line conductors (PLC) are full-wave-rectified in the full-wave rectifier (FWR) and provided to the B+/B- terminals in the form of unfiltered full-wave-rectified 277Volt/60Hz voltage. Thus, the DC voltage provided between the B+ bus and the B- bus consists of unidirectional sinusoidally-shaped voltage pulses occurring at the rate of 120 per second. In other words, the instantaneous magnitude or the DC supply voltage is substantially equal to the instantaneous absolute magnitude of the 277Volt/60Hz power line voltage.

Detailed operation of the half-bridge inverter (HBI) is explained in U.S. patent No. 4,506,318 to Nilssen.

In particular, the two series-connected transistors (Q1/Q2) in combination with the two series-connected capacitors (C1/C2) and the two feedback current transformers (CT1/CT2) act as a 30 kHz self-oscillating half-bridge inverter; which inverter is powered by the unfiltered full-wave-rectified 277Volt/60Hz power line voltage.

This inverter is of a type that needs to be triggered into oscillation, and that drops out of oscillation whenever the B+ voltage falls below a given relatively low magnitude.

Hence, near the end of each individual pulse of the full-wave-rectified 277Volt/60Hz DC supply voltage, the inverter ceases oscillation; and it then has to be re-triggered to start oscillation again.

The time constant associated with resistors FR and AR as combined with capacitor Ct can be adjusted such as to cause the capacitor to reach a voltage-magnitude high enough to cause the Diac (D1) to trigger at substantially any position during each individual pulse of the unfiltered DC voltage. By adjusting the resistance value of AR, the trigger point can be adjusted over a wide range; which means that the RMS magnitude of the inverter's output voltage can be correspondingly adjusted to nearly any RMS value lower than that present when triggering occurs at the very beginning of each pulse of the DC supply voltage.

It is noted that the instantaneous absolute magnitude of the voltage provided at the inverter's output -- i.e., the output provided between junction JC and point X -- is substantially equal to half that of the DC supply voltage. Thus, as long as it is oscillating, the half-bridge inverter (HBI) acts to reduce the RMS magnitude of the DC supply voltage by a factor of two.

In other words, since the RMS magnitude of the DC supply voltage is substantially equal to that of the 277Volt/60Hz power line voltage, as long as the inverter indeed oscillates, the RMS magnitude of the output of the half-bridge inverter (HBI) is substantially equal to half that of the 277Volt/60Hz power line voltage; which is to say that it will be equal to about 138.5 Volt as long as the inverter oscillates in a substantially continuous mode.

However, by suitably delaying the point at which the inverter is triggered into oscillation at the beginning of each sinusoidally-shaped unidirectional voltage pulse of the DC supply voltage, a further reduction of the RMS magnitude of the inverter's output can readily be attained.

Specifically, by delaying the trigger point approximately 65 degrees, the net RMS magnitude of the inverter output voltage will be reduced to approximately 120 Volt.

The net overall power factor resulting from this amount of phase delay is about 88%; which is to say that to reduce the RMS magnitude from 138.5 Volt (half of 277 Volt) to 120 Volt (by way of phase-control similar to that used in a Triac-type light dimmer) results in a power factor of about 88%.

Additional Comments

a) In view of the explanation of the operation of the arrangement of Fig. 1, the operation of the arrangements illustrated in Figs. 2-4 is substantially self-explanatory.

b) Since the frequency of the output voltage from the half-bridge inverter (30 kHz) is so very much higher than the 60 Hz on the power line, any power transformer for changing the RMS magnitude of the 120Volt/30kHz inverter output voltage becomes very small and inexpensive. This particular fact is taken into account by showing one of the lighting units (LU2 of Fig. 1 or STLU2 of Fig. 4) as having a 12 Volt Tungsten-Halogen lamp powered by way of a 30 kHz 120Volt-to-12Volt ferrite transformer.

c) Of course, the reduction from 277 Volt RMS to 120 Volt RMS may be accomplished directly by way of a light-dimming-type approach -- such as by using a Triac. However, the resulting power factor would then be less than 44% or so (i.e., equal to the ratio of 120 to 277); which generally would be considered unacceptably low.

d) With a distribution voltage of 240 Volt RMS magnitude, there is no need for RMS magnitude-reduction beyond that which is attained directly by way of the half-bridge inverter; in which case the resulting power factor will be just about 100%.

e) With an efficiency of about 99% for the full-bridge rectifier (FBR) and about 98% for the half-bridge inverter (HBI), the overall output-to-input efficiency of the electronic voltage conditioner (EVC) is about 97%.

f) Since the efficiency is so very high, and since no power transformer is used, the overall size of the complete electronic voltage conditioner (EVC) can be very small: small enough to be integrally included as element SEVC of the special power track (SPT) in the special track lighting system of Fig. 4.

g) If an overall power factor of 88% should in some situations prove to be inadequate, increased power factor can readily be attained by providing for a very small 30 kHz auto-transformer between the output of the half-bridge inverter (HBI) and the output/distribution conductors (ODC), and arranged such as to yield a slightly reduced-magnitude voltage to the ODC.

h) By providing for light-responsive feedback to control the firing angle of the half-bridge inverter, it is readily possible to maintain constant the RMS magnitude provided to the output/distribution conductors (ODC) regardless of significant changes in the RMS magnitude of the 277Volt/60Hz power line voltage.

i) It is noted that the capacitance of capacitors C1 and C2 of Fig. 1 need only be adequate to provide for a fairly low impedance path for currents of 30 kHz frequency; which implies that they can be very compact of size.

j) The fact that a half-bridge inverter operates in such manner as to provide an output voltage having an instantaneous magnitude that is substantially equal to half that of the DC supply voltage, might be understood by recognizing that in such an inverter the load means is connected between a center-tap of the DC supply (i.e., the junction JC between capacitors C1 and C2 in Fig. 1) and a point (X in Fig. 1)) that is alternatingly connected with the B+ bus and the B- bus.

k) It is believed that the present invention and its several attendant advantages and features will be understood from the preceeding description. However, without departing from the spirit of the invention, changes may be made in its form and in the construction and interrelationships of its component parts, the form herein presented merely representing the presently preferred embodiment.